A STUDY OF THE URINOGENITAL SYSTEM OF PHILIPPINE SALIENTIA, TOGETHER WITH NOTES ON CORNUFER NOVÆ-BRITANNÆ FROM NEW GUINEA AND A NORTH BORNEAN RHACOPHORUS OTILOPHUS

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FIVE PLATES AND NINE TEXT FIGURES

INTRODUCTION

The Philippines with her varied environments provide ecological niches occupied by diverse interesting salientian forms. In his "Systematics and Zoogeography of Philippine Amphibia," Inger (1954) has given useful data on the egg-size and peculiar breeding habits of some of the salientians. Very recently Alcala (1962) has elaborated on the breeding behavior and early development of some of these Philippine frogs. The series of studies made by Bhaduri, et al. [Bhaduri (1932, 1946, and 1953); Bhaduri and Basu (1957); Bhaduri and Mondal (1962); Bhaduri and Benerjee in MS.] on the urinogenital organs of salientians, in which they have included known facts of breeding habits and have described, *inter alia*, the modification of the Wolffian and Müllerian ducts, the occurrence of a urinogenital sinus, the extent of union of the uteri and their opening and closure in the cloaca before and after spawning, etc., have clearly demonstrated some interesting nexus between structures and functions.

Bhaduri (1953) in his work on the urinogential system of salientians has provided a historical résumé of the subject as a whole. His work, however, has still left some lacunæ to be filled in by investigations of forms that show interesting breeding habits or deviations from the usual pattern of urinogenital organization exhibited by common frogs (*Rana*) or toads (*Bufo*). Of the four genera of the Discoglossidæ, *Bar-*

bourula has not been studied by any investigator. Some anatomical data on the other three genera (*Alytes, Bombina,* and *Discoglossus*) are available from studies by von Wittich (1853), Spengel (1876), Boulenger (1896), Gadow (1901), Boonacker (1927), and Noble (1931). However, their observations show a good deal of confusion regarding the course and fate of the Wolffian and Müllerian ducts in the cloaca of the males only.

In the male of *Alytes obstetricans,* according to Boonacker (1927), the duct which conveys the sperm is not the Müllerian duct, as Spengel (1876) and Boulenger (1896) thought, but it is homologous with the Wolffian duct. The Müllerian ducts are quite separate from the Wolffian ducts, although both may be united anteriorly. In *Alytes, Bombina,* and *Discoglossus* there are separate openings of the Wolffian ducts into the cloaca, as reported by Spengel (1876), but Boulenger (1896) has reported a seminal vesicle for the males of the aforesaid genera. And this has been confirmed by Noble (1931) in *Alytes* only. Spengel (1876) has stated that there is a union of the Müllerian ducts in the females of A. *obstetricans* and *B. Bombina,* but they are separate in *D. pictus.* It is worth mentioning that a vestigial Müllerian duct in various forms of development persist in the males of such discoglossid genera as *Alytes* [Spengel (1876), Boulenger (1896), Gadow (1901), Boonacker (1927)], *Bombina* [Leydig (1853), von Wittich (1853), Spengel (1876)], and *Discoglossus* [von Wittich (1853), Spengel (1876), Gadow (1901)]. Gadow (1901), however, states that all traces of these ducts seem to have vanished at least in the adult stage of *Alytes* and *Discoglossus.* Thus, a careful perusal of their papers will make it evident that no attempt has so far been made to correlate the structure of the urinogenital organs with the breeding habits of these genera, nor the uterine fusion, as reported in *Alytes* and *Bombina,* with the size of the eggs. Here we have an opportunity to study a very rare and interesting discoglossid genus, *Barbourula* which is entirely confined to the Philippines. *Barbourula,* though an aquatic breeder like *Discoglossus,* is remarkable indeed in the possession of large-sized ova and united uteri, like those found in the females of *Alytes* and *Bombina,* and a vestigial Müllerian duct in the male. Thus, *Barbourula* shows striking similarities with *Alytes* and *Bombina,* though it stands apart from *Discoglossus.*

The urinogenital system of Philippine Salientia has not been studied so far. Thirteen species belonging to eleven genera of six families of Salientia; namely, Discoglossidæ, Pelobatidæ, Bufonidæ, Ranidæ, Rhacophoridæ, and Microhylidæ as defined by Inger (1954) and (1956) have been investigated. In all the genera, excluding *Megophrys* and *Rhacophorus*, the urinogenital system is described for the first time. An attempt also has been made to correlate their structural modifications with data on the breeding habits of the animals.

MATERIALS AND METHOD

Eleven species of Philippine Salientia together with a ranid *Cornufer novæ-britannæ* from New Guinea and a rhacophorid, *Rhacophorus otilophus* from North Borneo form the materials for this study. The localities, date of collections and other relevant information are given under each species.

Ten of the thirteen species are represented by both sexes, two by males and only one by a female.

Both sexes of:

1. *Barbourula busuangensis* Taylor and Noble.
2. *Megophrys monticola stejnegeri* Kuhl and van Hasselt.
3. *Ansonia muelleri* Boulenger.
4. *Ooeidozyga lævis lævis* Günther.
5. *Staurois natator* Günther.
6. *Cornufer meyeri* Günther.
7. *Cornufer corrugatus* Duméril.
8. *Cornufer novæ-britannæ* (Werner).
9. *Kaloula picta* Duméril et Bibron.
10. *Kalophrynus pleurostigma pleurostigma* Tschudi.

Males only of:

11. *Rhacophorus otilophus* Boulenger.
12. *Philautus longicrus* Boulenger.

Female only of:

13. *Oreophryne annulata* (Stejneger).

All the specimens were well preserved and found satisfactory for the study of the urinogenital organs.

After a careful and thorough topographic study of the urinogenital organs of each specimen under a binocular dissecting microscope, the hind gut along with the accompanying urinogenital ducts was dissected out from the pelvic complex. It was then thoroughly washed with water, dehydrated through alcohol grades and finally embedded in paraffin for sectioning.

Serial transverse sections of 10-micron thickness, stained with hæmalum-eosin were used for microscopic examinations in order to trace the course and fate of the ducts. In the males of *Barbourula busuangensis* and *Rhacophorus otilophus* the kidneys with the associated ducts were also sectioned for the investigation of some special points.

The terminology used for the urinogenital organs is as defined by Bhaduri [(1953) 10–12].

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OBSERVATIONS

DISCOGLOSSIDÆ

BARBOURULA BUSUANGENSIS Taylor and Noble.

Male.—Size: from snout to vent 66.8 mm (CNHM 51012, HH 2782).

Locality.—Dimaniang near sea level; Busuanga: Philippines, March 21, 1947 (*Natives*).

The kidneys are symmetrical in shape, size and position. They are nonlobed brown organs being closely juxtaposed at their inner margins. Each kidney is peculiar in having a blunt and broadened anterior and a tapering posterior end. The ventral surface is flat and the dorsal slightly convex. The kidney measurements are: right, 19.5 × 4.7 mm, and left, 19.5 × 5.1 mm.

The testes are small nonpigmented yellowish, globular bodies and lie at about the same level ventral to the anterior region of the kidneys. The left testis is a trifle longer and stouter than the right one. They are held firmly to the kidneys by the mesorchia through which pass two or three vasa efferentia on each side. The right testis measures 4.4 × 2.6 mm, and left, 4.8 × 3 mm. The fat-bodies are moderately developed and yellowish in color with but a few digitations on each side.

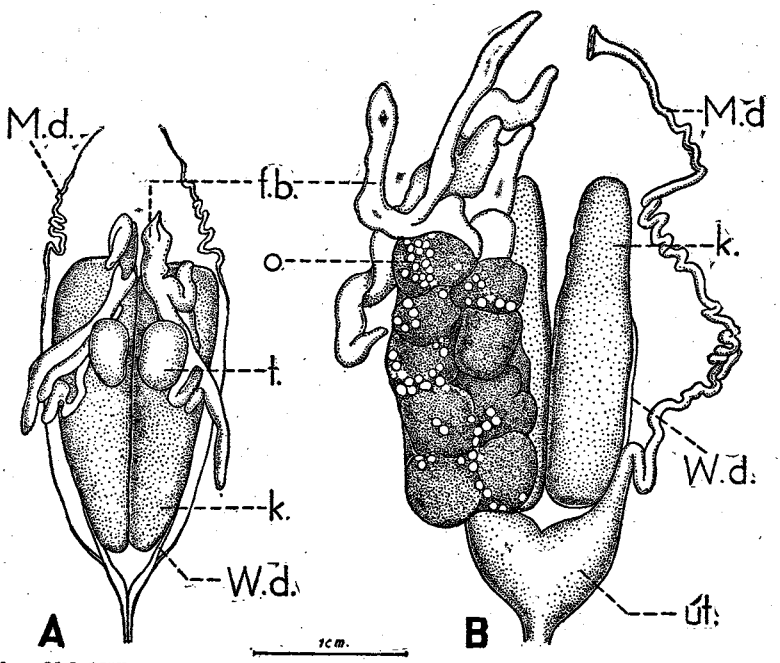
The Wolffian ducts are thick-walled and narrow throughout their entire length. After leaving the kidneys they run in close apposition to each other, being separated only by fibrous tissue. The two ducts open separately into the cloaca.

The Müllerian ducts are rather very prominent and run as whitish cords parallel to the outer lateral edges of the kidneys. Anteriorly they are thrown off into several small coilings and extending as far as the root of the lungs. Serial histological sections reveal that behind the kidneys they gradually diminish in diameter and run for some distance as pigmented cords which finally end blindly in the cloacal wall. Furthermore, the convoluted region of these vestigial Müllerian ducts is glandular and provided with some secretory mass inside their lumina.

The bilobed urinary bladder is large and very thick-walled. It opens ventrally into the cloaca opposite the separate openings of the Wolffian ducts. (Text fig. 1A; Plate 1, figs. 1–2.)

Female.—Size: from snout to vent 75.7 mm (CNHM 51016, HH 2786).

Other data same as in the male.



[Abbr.: *M.d.* Müllerian duct: *f. b.*, fat-body; *o.*, ovary; *t.*, testis; *k.*, kidney; *W.d.*, Wolffian duct.]

FIG. 1. Diagramatic ventral views of the urinogenital organs of *Barbourula busuangensis: A*, male; *B*, female (the left ovary with fat-bodies not shown).

The kidneys are unlike those of the male. They are gradually divergent anteriorly from about their middle region, and are closely juxtaposed posteriorly. The right kidney measures 22.3 × 4.6 mm, and left 22 × 4.6 mm.

The ovaries are much compressed, thin-walled sacs containing ova at various stages of development. The left ovary is bilobed, while the right has only one lobe. The larger ova measuring about 3 to 3.2 mm are nonpigmented and brownish in color and the smaller immature ones are whitish. The fat-bodies attached to the ovary are well developed and deep brown in color being provided with a number of long branched digitations.

The pars recta of the oviduct is fairly long and is distinguished from the pars convoluta which is but slightly coiled. Immediately behind the kidneys the pars convoluta expands into a large thin-walled uterus. The two uteri approach each other mesially and coalesce into a common uterus at their point of contact, which runs towards the cloaca diminishing gradually in diameter. Serial histological sections reveal that the inner lining wall of the common uterus is provided with small villi and is glandular, containing some secretory mass inside. The common uterus is gradually incorporated into the cloacal wall, where it forms a urinogenital papilla in its lumen and finally opens into the cloaca. The maturity of the specimen, and the condition of the ovary and oviducts suggest that the uterine opening has just recently been established in preparation for spawning. (Text fig. 1B; Plate 1, figs. 3–4.)

The Wolffian ducts originate from the anterior third of the kidneys from their outer ends. As they leave the kidneys they pass dorsally over the common uterus, where the two ducts lie separated by a common partition wall. They unite terminally and the common duct opens into the cloaca after running for about 0.15 mm.

The urinary bladder is as in the male.

PELOBATIDÆ

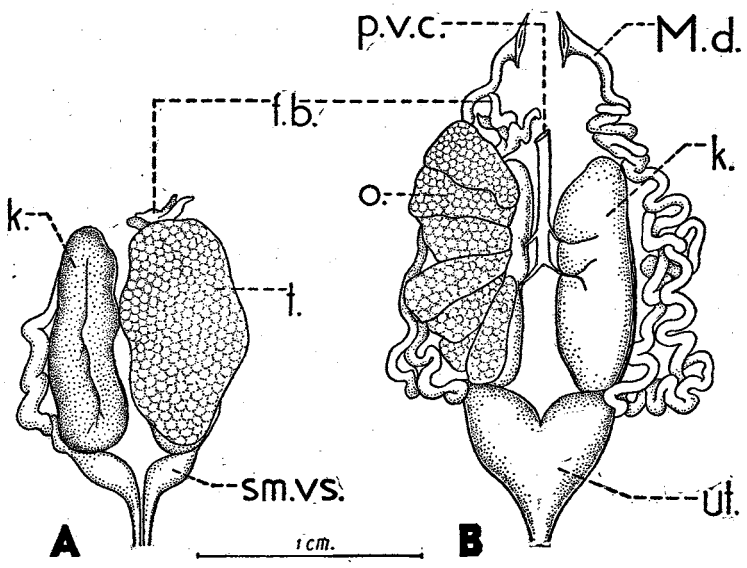
MEGOPHRYS MONTICOLA STEJNEGERI Taylor.

Male.—Size: from snout to vent 47.6 mm (CNHM 50931).

Locality and habitat.—Stream in abaca plantation, east slope Mt. McKinley 2,800 ft., Davao Province, Mindanao: Philippines,

August 30, 1946 (*Pascual Convocar*).

The kidneys are elongated oval in shape and are nonlobed. They measure: right, 10 × 3.3 mm, and left, 10.7 × 3.8 mm. The most remarkable feature is the enormous size of the testes which cover the kidneys almost completely from the ventral view. They are unpigmented, yellowish and elongated-oval in shape. The mesorchium is compact, through which five or six vasa efferentia are discernible. They measure: right, 8.7 × 5.5 mm, and left, 10 × 5 mm. Fat-bodies consist of three or four small digitations. The Wolffian duct arises from about the anterior end of the kidney and gradually increases in diameter as it runs along its outer border. At about the middle level of the kidneys the ducts are thrown into several folds without having any transverse connecting ducts from the kidneys. After leaving the kidneys they dilate into spindle-shaped vesicula seminales and finally open separately into the cloaca through small urinogenital papillæ. The urinary bladder is thin-walled. (Text fig. 2A; Plate 1, fig. 5.)



[Abbr.: *k.*, kidney; *f.b.*, fat-body; *t.*, testis; *sm. vs.*, vesicula seminalis; *o.*, ovary; ***M.d.***, Müllerian duct; *ut.*, uterus; *p.v.c.*, post canal vein.]

FIG. 2. Diagrammatic ventral views of the urinogenital organs of *Megophrys monticola*. *A*, male (the right testis with fat-bodies not shown); *B*, female (the left ovary with fat-bodies not shown).

Female.—Size: from snout to vent 62 mm (CNHM 50940, HH 921).

Locality and Habitat.—Mt. Apo, Todaya 2,800 feet, Davao Province, Mindanao: Philippines, November, 1946 (*Natives*).

The kidneys are imperfectly lobed at their mesial borders. They measure: right, 10.3 × 4.3 mm, and left, 10.6 × 4.1 mm. The ovaries are of ranid type, and provided with seven lobes on the right and eight on the left. The ovarian ova are small and are in various stages of development and on an average measure 1 mm. Fat-bodies consist of two or three short orange colored digitations. The oviducts are fairly well developed. The pars recta is short and the pars convoluta is much coiled. The two uteri are united at their point of contact. The terminal end of common uterus remains unopened forming a papilla that bulges into the cloacal lumen (Plate 2, fig. 7). The bulging papilla and the condition of the ovary and the oviducts seem to suggest that an opening would soon be established. The Wolffian ducts are uneventful in their course and have separate openings into the cloaca. The urinary bladder is as in the male. (Text fig. 2B; Plate 2, figs. 6–7.)

BUFONIDÆ

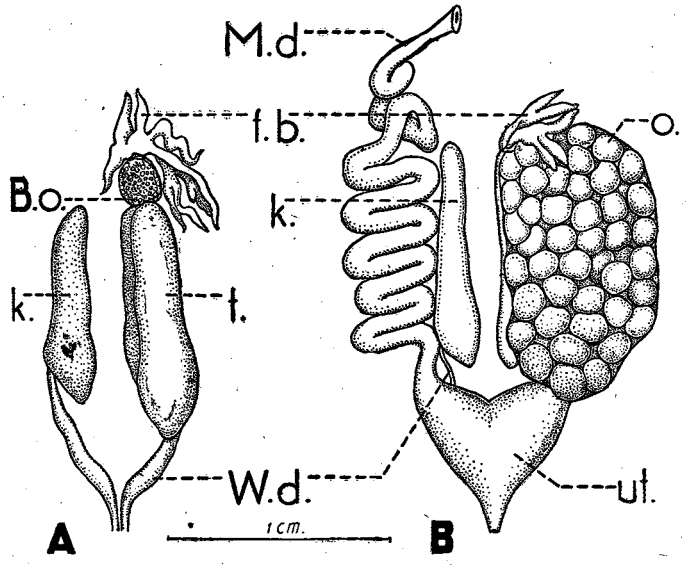
ANSONIA MUELLERI Boulenger.

Male.—Size: from snout to vent 25.6 mm (CNHM 50901, HH 2135).

Locality.—Mt. Apo, Todaya 2,800 feet, Davao Province, Mindanao: Philippines, November, 1946 (*Natives*).

The kidney pattern is unlike that of *Bufo*. The kidneys are nonlobed, light brown, elongate and dorso-ventrally flattened organs, each consisting of a thin narrow anterior portion occupying about two-thirds the length of the kidney and the posterior third is broad and compact. They measure: right, 6.4 × 1.9 mm, and left, 7 × 1.6 mm. The testes are symmetrically disposed large cylindrical bodies with but slight pigmentation, completely obscuring the kidneys from ventral view. There are ten to twelve vasa efferentia. The testes measurements are right, 6.5 × 2.2 mm, and left, 8.1 × 2.1 mm. Bidder's organ with fat-bodies are moderately developed and attached to the caput of the testis, as are usually present in *Bufo*. Wolfian ducts with spindle-shaped seminal vesicles run their usual course and open separately into the cloaca. No trace of

Müllerian ducts could be discerned, even in sections. The urinary bladder is thin-walled and bilobed. (Text fig. 3A; Plate 2, fig. 8.)



[Abb.: *B.o.*, Bidder's organ *k.*, kidney; *M.d.*, Müllerian duct; *f.b*, fat-body; *t.*, testis; *W.d.*, Wolffian duct; *o.*, ovary; *ut.*, uterus.]

FIG. 3. Diagrammatic ventral views of the urinogenital organs of *Ansonia muelleri*. *A*, male (the right testis together with Bidder's organ and bodies, and the left oviduct not shown).

Female.—Size: from snout to vent 31.4 mm (CNHM 50872, HH 2028).

Other data same as in the male.

The kidneys are unlike those of the male. They are greatly elongated, much compressed nonlobed symmetrical bodies of about equal length. The anterior portion is somewhat narrow when compared to that of the posterior portion. The kidney measurements are: right, 10 × 1.5 mm, and left, 10.5 × 1.5 mm. The ovaries are enormous, with two lobes on either side. Eggs are large and nonpigmented with the number varying between eighty and eighty-five per ovary, and measure about 2.1 mm on an average. The fat-bodies are small with five or six digitations. The oviducts are well developed. The pars recta is short. Pars convoluta is well developed and glandular with but a few convolutions. The uteri are united at

their point of contact. The common uterus forms a bulging papilla into the cloacal lumen which remains unopened but suggesting a near establishment of an opening. The Wolffian ducts have separate openings into the cloaca. The urinary bladder is as in the male. (Text fig. 3B; Plate 2, figs. 9–10.)

RANIDÆ

OOEIDOZYGA LÆVIS Günther.

Male.—Size: from snout to vent 33.1 mm (CNHM 57083).

Locality and habitat.—Pamoat in small stream emptying into Sicopon River, Amio; Negros: Philippines, May 1–5, 1948 (*D. S. Rabor*).

The asymmetrically placed kidneys are elongated and dorso-ventrally flattened with their outer edges more convex than the mesial borders. They measure: right, 8.7 × 3 mm, and left, 7.4 × 3.3 mm. The testes are small ovoid bodies of about equal size and are distinctly asymmetrical in position. Five or seven vasa efferentia enter the kidneys from each side. They measure: right, 3 × 2 mm, and left, 3.1 × 1.5 mm. The fat-bodies are massive with a number of irregular digitations. Wolffian ducts possess spindle-shaped seminal vesicles and open separately into the cloaca. No trace of Müllerian ducts can be made out. The bilobed urinary bladder is large and thickish in the middle.

Female.—Size: from snout to vent 49.1 mm (CNHM 57196).

Locality and habitat.—Dumaguete in pond; Negros: Philippines, January 5, 1948 (*D. S. Rabor* and *D. Empeso*).

The urinogenital layout is essentially similar to that of an ordinary *Rana*.

The kidneys are flattened dorso-ventrally and are symmetrical in form and position. Their anterior ends are somewhat truncated and a little broader than the posterior. The kidney measurements are: right, 11 × 5 mm, and left, 12.4 × 4.5 mm. The ovaries are moderately large with three lobes on the right and four on the left. They contain ova at various stages of their development, the large ones measuring 2 mm on an average. The fat-bodies are broad and flat with a number of short digitations. The oviducts are well developed. Pars recta is short, followed by a much coiled pars convoluta. The two uteri open separately into the cloaca through huge bulging urinogenital papillæ. Histological sections reveal that the uteri are thick-walled with prominent longitudinal folds. Since this

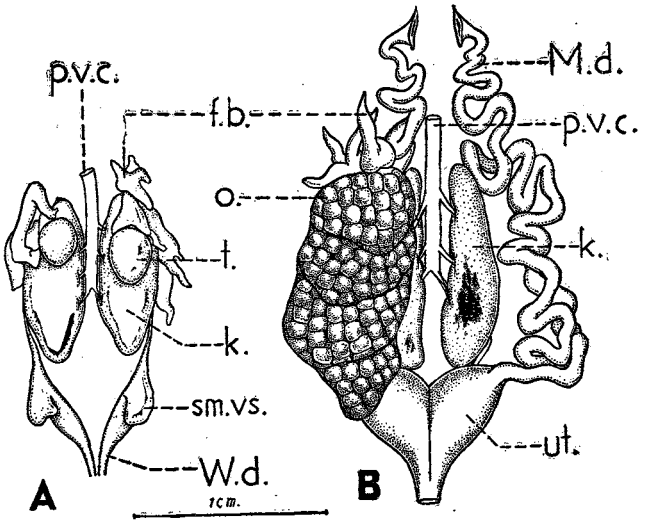
is a mature specimen and the reproductive organs are well developed, the uterine openings into the cloaca have been established presumably in preparation for spawning. Wolffian ducts are uneventful in their course and have separate openings into the cloaca. The urinary bladder is as in the male. (Plate 2, fig. 11.)

STRAUROIS NATATOR Günther.

Male.—Size: from snout to vent 37.5 mm (CNHM 50449, HH 2054).

Locality.—Mt. Apo, Todaya 2,800 feet, Davao Province, Mindanao: Philippines, November, 1946 (*Natives*).

The kidneys are dorso-ventrally flattened leaflike structures of about symmetrical position. Their outer lateral edges are broadly convex. The kidney measurements are: right, 8.8 × 3.5 mm, and left, 8.2 × 3.2 mm. The testes are small globular bodies with three or four vasa efferentia. They measure: right, 2.6 × 2.2 mm, and left, 3 × 2.1 mm. The fat-bodies are small with three- or four-branched digitations. The Wolffian ducts behind the kidneys expand laterally into large thick-walled vesicula seminales, and open separately into the cloaca.



[Abbr.: *p.v.c.*, posterior vena cava; *f.b.*, fat-body; *o.*, ovary; *t.*, testis; *k.*, kidney; *sm.vs.*, vesicula seminalis; *W.d.*, Wolffian duct; *M.d.*, Müllerian duct; *ut.*, uterus.]

FIG. 4. Diagrammatic ventral views of the urinogenital organs of *Staurois natator*. *A*, male; *B*, female (the left ovary with fat-bodies not shown).

Histological sections show the presence of many minute glandular chambers inside the seminal vesicles (Fig. 12). No trace of Müllerian ducts is discernible. The urinary bladder is extensive and thick-walled. (Text fig. 4A; Plate 3, fig. 12.)

Female.—Size: from snout to vent 44 mm (CNHM 50445, HH 2050).

Other data same as in the male.

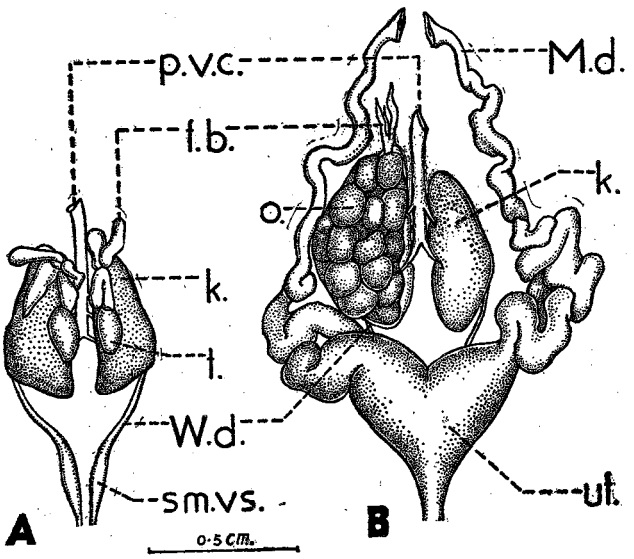
The elongated kidneys are symmetrical in size, shape and position. They are narrow anteriorly and posteriorly broad. The kidney measurements are: right, 10.2 × 3.1 mm, and left, 10.6 × 3.2 mm. Ovaries with four lobes on the right and five on the left, contain nonpigmented ova, apparently mature measuring on an average 2 mm. The fat-bodies are moderately developed with a number of pointed digitations. The oviducts are well developed and look much like those of a typical *Rana*. The pars recta is short and the pars convoluta is much coiled. A terminal union for about 1 mm characterizes the course of the uteri. The common uterus opens into the cloaca through a papilla. The condition of the ovary and the oviduct tends to suggest that the uterine opening had recently been established in preparation for spawning. Wolffian ducts run uneventfully and open separately into the cloaca. The urinary bladder is thin-walled. (Text fig. 4B; Plate 3, fig. 13.)

CORNUFER MEYERI Günther.

Male.—Size: from snout to vent 23.9 mm (CNHM 50565, HH 2185).

Locality and habitat.—Malalag near sea level on ground second growth forest, Davao Province, Mindanao: Philippines, November 29, 1946 (*Werner* and *Celestino*).

The kidneys are essentially of the ranid type. They are dorso-ventrally flattened, compressed, brownish structures of symmetrical size, form and position. The posterior half of each kidney is much broader than the anterior end. The kidney measurements are: right, 5.1 × 2.4 mm, and left, 4.5 × 2.2 mm. The asymmetrically placed ovoid testes are small and compressed with three vasa efferentia on either side. The testis measurements are: right, 1.9 × 0.7 mm, and left, 1.7 × 0.7 mm. The fat-bodies arising from the caput of the testes are massively built and consist of three or four yellowish flattened digitations. Wolffian ducts with spindle-shaped vesicula seminales, open separately into the cloaca. There is no



[Abbf.: *p.v.c.*, posterior vena cava; *f.b.* fat-body; *k.*, kidney; *t.*, testis; *W.d.*, Wolffiian duct; *sm.vs.*, Vesicula seminalis; *M.d.*, Müllerian duct; *o.*, ovary; *ut.*, uterus.]

FIG. 5. Diagrammatic ventral views of the urinogenital organs of *Cornufer meyeri*. *A*, male; *B*, female (the left ovary with fat-bodies not shown).

trace of Müllerian ducts. The urinary bladder is typically of the ranid type. (Text fig. 5A.)

Female.— Size: from snout to vent 34.2 mm (CNHM 50559, HH 2185).

Locality and habitat.—Calian sea level, ground second growth forest, Malita, Davao Province, Mindanao: Philippines, January 7, 1947 (*Celestino*).

The kidneys are more or less similar to those of the male. They measure: right, 6.2 × 2.1 mm, and left, 5.4 × 2 mm. The ovaries are peculiar in that each consists of a single sac. In each ovary there are found twenty or twenty-one large nonpigmented ova, of which a mature one measures 3.7 mm. The fat-bodies are insignificantly small with but three small digitations. The oviducts are well developed with a conspicuous pars convoluta. The pars recta is short. The pars convoluta is distinguishable into two portions: the anterior portion in having a few transverse folds and the posterior being greatly convoluted above the uteri. The uteri are fairly thick-walled and coalesce into a common uterus almost at their point of contact having a very short partition wall. Sections reveal

that longitudinal folds are prominent throughout the entire course of the uteri. The common uterus gets encroached into the cloacal lumen forming a huge bulging papilla but remaining unopened. Nevertheless, the condition of the ovary and oviducts tends to suggest that an opening will sooner or later be established. Wolffian ducts are uneventful in their course and open separately into the cloaca. The urinary bladder is as in the male. (Text fig. 5B; Plate 3, figs. 14–15.)

CORNUFER CORRUGATUS Dumeril.

Male.—Size: from snout to vent 31 mm (CNHM 50587, Mindanao 328).

Locality and habitat.— East slope Mt. McKinley 3,400 feet, on ground, second growth forest, Davao Province, Mindanao: Philippines, August 31, 1946 (*Castro*).

The kidneys are similar as in the preceding species. They measure: right, 6.8 × 2.3 mm, and left, 6.8 mm × 3 mm. The testes are black pigmented ovoidal bodies with three or four vasa efferentia on either side. They measure: right, 3 × 1.5 mm, and left, 2.9 × 1.5 mm. The fat-bodies are small and knoblike, each with two flattened digitations. Wolffian ducts with spindle-shaped vesicula seminales open separately into the cloaca. The vestigial Müllerian duct appears as a thin whitish cord extending forward as far as the root of the lung. It extends a little beyond the free portion of the Wolffian duct behind the kidney. The urinary bladder is as in the preceding species. (Plate 3, fig. 16.)

Female.—Size: from snout to vent 43.7 mm (CNHM 50542, Mindanao 403).

Locality and habitat.—East slope, Mt. McKinley 2,900 feet, on ground, original forest, Davao Province, Mindanao: Philippines, December 12, 1946 (*Añonuevo*).

The kidneys are typically of the ranid type, and are similar to those of the male. They measure: right, 8.4 × 3.8 mm, and left, 8 × 3.5 mm. The ovaries seem to be spent, and consist of single sacs, as in the preceding species. The ova are immature and are at various stages of development, of which the larger ones measure about 2 mm. The fat-bodies are insignificantly small, each with two small digits. The oviducts are well developed and greatly convoluted, the convolutions being especially marked at the posterior region of the kidneys. The pars recta is rather short. The two uteri with longitudinal folds inside unite almost at their point of contact

leaving behind a very short partition wall which soon disappears. The unpaired common uterus finally forms a papilla which bulges into the cloacal lumen and remains patent through a small slit at the summit of it. This condition together with the spent ovary tends to suggest that uterine opening is probably on the verge of closure after spawning. The Wolffian ducts are uneventful in their course and open separately into the cloaca. The urinary bladder is as in the preceding species. (Plates 3–4, figs. 17–18.)

CORNUFER NOVÆ-BRITANNÆ (Werner).

Male.—Size: from snout to vent 38 mm (CNHM 13860, R.F.I. 4).

Locality.—Rabaul, New Britain: Terr. New Guinea, April 26, 1929 (*Karl P. Schmidt*).

The general pattern and organization of the urinogenital system are as in the preceding species.

The kidney measurements are: right, 7.6 × 3.1 mm, and left, 7.1 × 3.2 mm. The ovoidal testes are provided with three vasa efferentia on the right and five on the left. They measure: right, 3 × 2.2 mm, and left, 2.9 × 2.3 mm. The fat-bodies are, however, massively built, each having six or seven pointed digitations. The Wolffian ducts are provided with spindle-shaped vesicula seminales. Posteriorly towards the cloaca they run parallel, being separated only by a common partition wall and finally open separately into the cloaca. There is no trace of the Müllerian ducts. The urinary bladder is of the usual ranid type.

Female.—Size: from snout to vent 54.5 mm (CNHM 13860, R.F.I. 5).

Other data same as in the male.

The disposition-pattern of the kidneys is more or less similar to that of the male, though the right kidney is distinctly longer than the left. The kidney measurements are: right, 9.4 × 3.4 mm, and left, 7.2 × 3.2 mm. The ovaries consist of single sacs containing nonpigmented immature ova at various stages of their development. A fairly large ovarian ovum measures 1.8 mm in diameter. The fat-bodies are moderately developed, each having a number of elongated digitations. Although the oviduct looks ill-developed, it has a few coilings at the posterior level of the kidney following a fairly long pars recta. The united uteri are provided with a very short partition wall. The common uterus remains unopened inside a papilla that

bulges in the cloacal lumen (Fig. 19). This together with the condition of the ovary and the oviducts seems to suggest its attaining sexual maturity for the first time. The Wolffian ducts are without the seminal vesicles but follow the same course and fate as in the male. The urinary bladder is fairly thick-walled. (Plate 4, fig. 19.)

RHACOPHORIDÆ

RHACOPHORUS OTILOPHUS Boulenger.

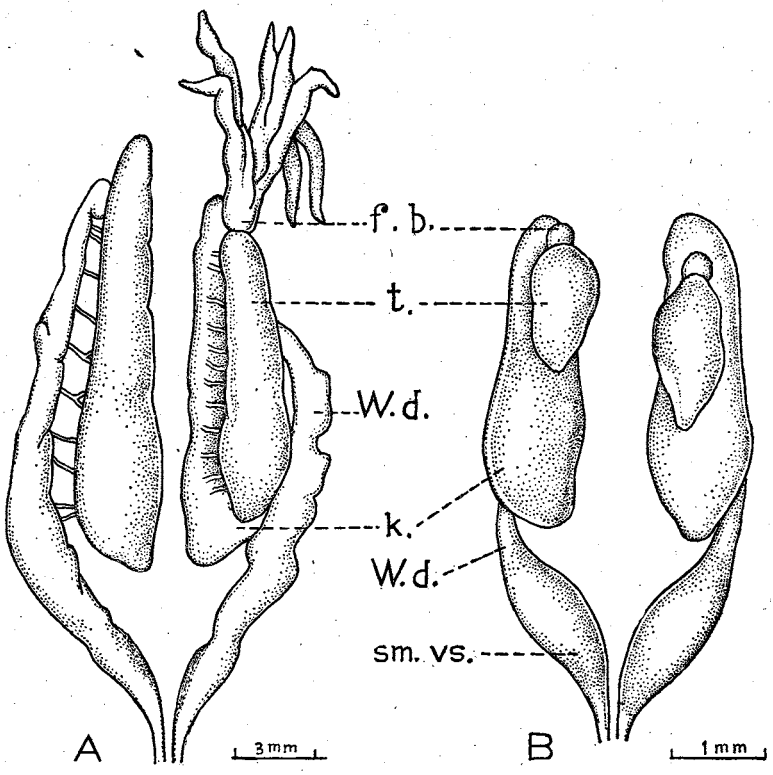
Male.—Size: from snout to vent 67.2 mm (CNHM 63435).

Locality.—North Borneo: East coast Residency; Kinabatangan District, Southeast end of Dewhurst Bay, Swampy area edge primary forest 5 feet above ground, night, calling, June 25, 1950 (*Robert F. Inger*).

The urogenital layout of the male is closely similar to that described for the males of *Rh. maximus* [Bhaduri (1932)] and *Chiromantis* [Hoffman (1932, 1942, and 1943); Bhaduri and Basu (1957)].

The kidneys are symmetrical in position and placed in close apposition, their inner margins being almost straight. Each kidney is distinguishable into two regions: the anterior thin and narrow portion occupying about two-thirds of the length of the kidney and the posterior third is broad and compact. The kidney measurements are: right, 18.9 × 3.3 mm, and left, 16.7 × 3.6 mm. The testes are nonpigmented, elegantly elongated organs of uniform thickness. Vasa efferentia eleven or fourteen on either side, are distributed along the entire length of the testes. The testis measurements are: right, 15.2 × 5 mm, and left, 13 × 4.7 mm. The fat-bodies consist of a basal stalk having three-folded lobes and eight or ten long tapering digitations. No less striking than the kidneys are the Wolffian ducts which show the same characteristic pattern and disposition as are seen in those of the males of *Rhacophorus* and *Chiromantis*. Each Wolffian duct commences as a separate tube from the outer border of the anterior thinner portion of the kidney and as it courses posterad the size of its lumen increases along with the complexity of its coils. It receives additional transverse ducts from the outer margin of the kidney along its whole length. The two ducts behind the kidneys come close together and open separately into the cloaca opposite the opening of the urinary bladder. Histological sections reveal that the portions of the Wolffian ducts lying adjacent to the kidneys are highly glandular and their inner lining wall is

thrown into villilike processes, especially well marked at the posterior region of the kidneys. These villose projections gradually diminish in height as the ducts course towards the cloaca. The urinary bladder is extensive, thin-walled and bilobed. (Text fig. 6A; Plate 4, figs. 20–22.)



[Abbr.: *f.b.*, fat-body; *t.*, testis; *W.d.*, Wolffian duct; *k.*, kidney; *sm.vs.*, vesicula seminalis.]

FIG. 6. Diagrammatic ventral views of the urinogenital organs of the male rhacophorids. *A*, *Rhacophorus otilophus* (the right testis with fat-bodies not represented); *B*, *Philautus longicrus*.

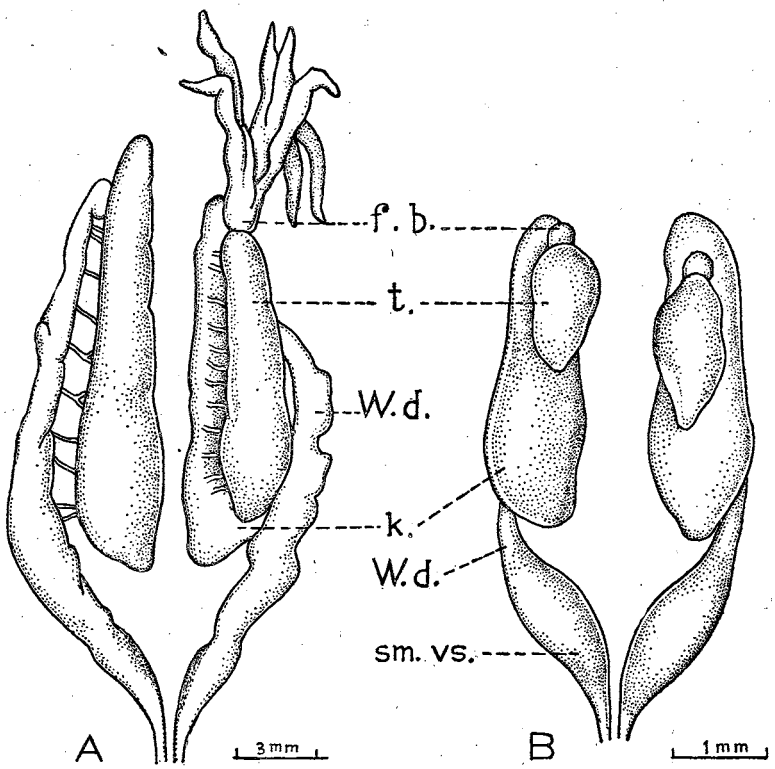
PHILAUTUS LONGICRUS Boulenger.

Male.—Size: from snout to vent 20.5 mm (CNHM 51338).

Locality.—Philippines: Palawan; Brooke's Point, south slope Mt. Balabag 2,800 feet, low vegetation along stream, May 5, 1947 (*F. Werner*).

The kidney pattern in this species differs from those described for the other rhacophorid genera. Essentially they are of ranid type. The kidneys are nonlobed symmetrically placed

thrown into villilike processes, especially well marked at the posterior region of the kidneys. These villose projections gradually diminish in height as the ducts course towards the cloaca. The urinary bladder is extensive, thin-walled and bilobed. (Text fig. 6A; Plate 4, figs. 20–22.)



[Abbr.: *f.b.*, fat-body; *t.*, testis; *W.d.*, Wolffian duct; *k.*, kidney; *sm.vs.*, vesicula seminalis.]

FIG. 6. Diagrammatic ventral views of the urinogenital organs of the male rhacophorids. *A*, *Rhacophorus otilophus* (the right testis with fat-bodies not represented); *B*, *Philautus longicrus*.

PHILAUTUS LONGICRUS Boulenger.

Male.—Size: from snout to vent 20.5 mm (CNHM 51338).

Locality.—Philippines: Palawan; Brooke's Point, south slope Mt. Balabag 2,800 feet, low vegetation along stream, May 5, 1947 (*F. Werner*).

The kidney pattern in this species differs from those described for the other rhacophorid genera. Essentially they are of ranid type. The kidneys are nonlobed symmetrically placed

organs of equal length. Each kidney has an elongated oval base being provided with an anterior narrow neck. The kidney measurements are: right, 3.5 × 1.3 mm, and left, 3.5 × 1.2 mm. The asymmetrically placed testes are moderately compressed bodies like those of *Cornufer meyeri*, with their posterior ends fairly pointed. Three or four vasa efferentia enter the kidneys through the compact mesorchia. The testis measurements are: right, 2 × 1 mm, and left, 1.7 × 1 mm. The fat-bodies are peculiar in that they are insignificantly small and globular in shape and do not exhibit any digitation. The Wolffian ducts arise from the posterior end of the kidneys and in the free posterior region they dilate greatly into bottle-shaped vesicula seminales. In this respect they may be compared with those of *Eleutherodactylus* [Bhaduri (1953)] and *Sminthillus* [Griffiths (1959)], except that the ducts do not unite at the posterior end. They run close together towards the cloaca and open separately into it. Histological sections reveal that the inner lining wall of the seminal vesicles is raised into a number of small villilike processes which disappear towards the posterior end. There is no trace of the Müllerian ducts. The urinary bladder is thin-walled, extensive and bilobed. (Text fig. 6B; Plate 4, fig. 23.)

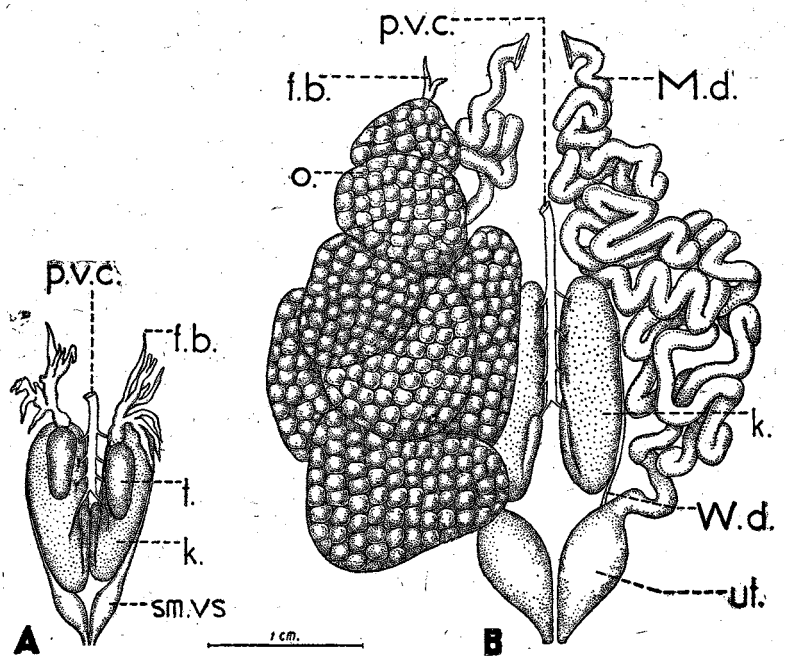
MICROHYLIDÆ

KALOULA PICTA Duméril et Bibron.

Male.—Size: from snout to vent 42.5 mm (CNHM 51573).

Locality.—Sea level, Cuyo Island, Mindanao: Philippines, May 29, 1947 (*Castro* and *Añonuevo*).

The elongated kidneys are dorso-ventrally flattened and are asymmetrical both in size and in position. There is an incipient postero-mesial lobe in both the kidneys, as is found in some microhylid genera [Devanesen (1912); Bhaduri and Rudra (1944); Bhaduri (1953); Bhaduri and Mondal (1962)]. The kidney measurements are: right, 11.4 × 3.1 mm, and left, 10 × 3 mm. The asymmetrically placed testes are cream-colored, elongate, and more or less cylindrical in shape. Three or four vasa efferentia enter the kidneys through compact mesorchia on either side. The testis measurements are right, 4.8 × 2.3 mm, and left, 5.1 × 1.9 mm. The fat-bodies are divided into two main lobes at the point of their attachment to the testes, and each lobe splits into a number of short fingerlike digitations. Wolffian ducts with spindle-shaped vesicula seminales open separa-



[Abbr.: *p.v.c.*, Posterior vena cava; *f.b.*, fat-body; *t.* testis; *k.* kidney; *sm.vs.* vesicula seminalis; *o.*, ovary; *M.d.*, Müllerian duct; *W.d.*, Wolffian duct; *ut.*, uterus.]

FIG. 7. Diagrammatic ventral views of the urinogenital organs of *Kaloula picta*. *A*, male; *B*, female (the right ovary with fat-bodies not shown).

tely into the cloaca. The bilobed urinary bladder is large and thin-walled. (Text fig. 7A.)

Female.—Size: from snout to vent 46 mm (CNHM 51555). Other data same as in the male.

The nonlobed kidneys are more or less symmetrical both in form and in position. Like the male, there is an inner incipient postero-mesial lobe in both the kidneys. The kidney measurements are: right, 14.9 × 4 mm, and left, 15.3 × 3.8 mm. The ovaries are of the ranid type. There are six lobes on the right and seven on the left. Ova are numerous and pigmented with a dark brown animal pole, and measure on an average 2 mm. The fat-bodies are minute with two short digitations. The oviducts are well developed and greatly convoluted, especially above the anterior level of the kidneys. The pars recta is almost absent. The uteri with prominent villose projections and some secretory mass inside as are revealed by serial cross sections open separately into the cloaca through two immense cloacal papillæ

that bulge into the cloacal lumen (Plate 5, fig. 24). This suggests that they had recently ruptured in preparation for spawning. The Wolffian ducts are uneventful in their course and open separately into the cloaca. The urinary bladder is as in the male. (Text fig. 7B; Plate 5, fig. 24.)

KALOPHRYNUS PLEUROSTIGMA PLEUROSTIGMA Tschudi.

Male.—Size: from snout to vent 37 mm (CNHM 50733, HH 1518).

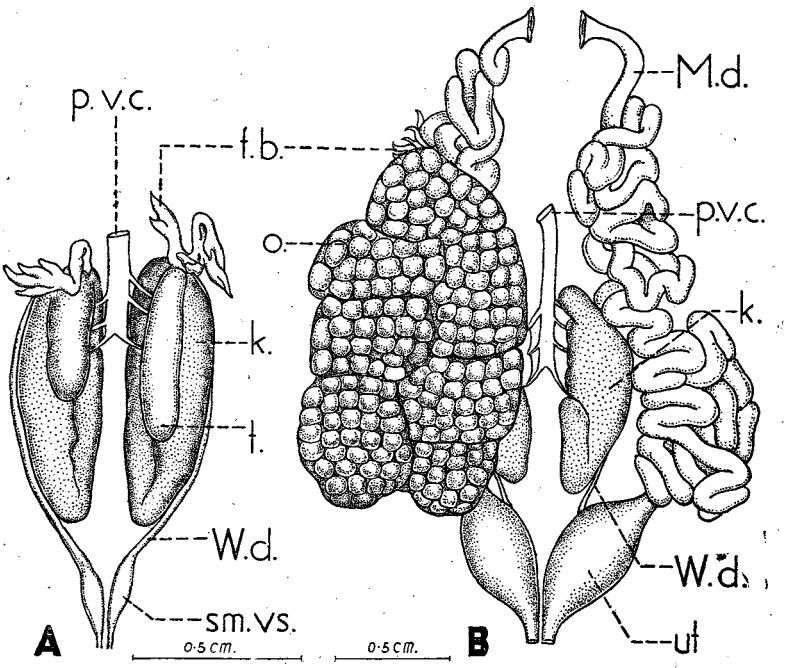
Locality and Habitat.—Calian Sea level under leaves and rocks, bank of stream, Malita, Davao Province, Mindanao: Philippines, January 15, 1947 (*Celestino*).

The kidneys are semilunar in shape and are asymmetrical both in size and in position. The most peculiar feature is a cylindrical lobe which is folded upon the inner mesial border of the posterior portion of the kidneys extending forwards as far as the anterior third. The kidney measurements are: right 7.2 × 2.6 mm, and left, 7.8 × 2.5 mm. Like the kidneys, the much elongated and cylindrical testes are also asymmetrical both in size and in position. Two or four vasa efferentia enter the kidneys on either side through the compact mesorchia. The testis measurements are: right, 3.8 × 1.6 mm, and left, 5 × 1.4 mm. The fat-bodies are very peculiar being narrow and ribbon-shaped, each with two or three branched digitations. Wolffian ducts with spindle-shaped vesicula seminales, open separately into the cloaca. Some scattered sperms are observed within the lumina of these ducts. There is no trace of the Müllerian ducts. Urinary bladder is thin-walled. (Text fig. 8A; Plate 5, figs. 25–27.)

Female.—Size: from snout to vent 45 mm (CNHM 50714, Mindanao 69).

Locality.—Mt. McKinley, east slope 3,300 feet, Davao Province, Mindanao: Philippines, August 13, 1946 (*Hegneman*).

The shape of the kidneys is unlike that of the male. They are much compressed and light brownish organs with three or four imperfect lobes at their inner margins; and their outer lateral margins are broadly convex. The kidneys are distinctly asymmetrical both in size and in position. Like that of the male, there is a prominent cylindrical postero-mesial fold in both the kidneys extending a little beyond their posterior half. The kidney measurements are: right, 9.7 × 3.9 mm, and left, 9 × 3.1 mm. The well-developed ovaries with seven lobes on the right and six on the left, contain numerous pigmented eggs



[Abbr.: *p.v.c.*, Posterior vena cava; *f.b.*, fat-body; *k.*, kidney; *t.*, testis; *W.d.*, Wolffian duct; *sm.vs.*, vesicula seminalis; *o.*, ovary; *M.d.*, Müllerian duct; *ut.*, uterus.]

FIG. 8. Diagrammatic ventral views of the urinogenital organs of *Kalophrynus pleurostigma*. *A*, male; *B*, female (left ovary with fat-bodies not shown).

in various stages of their development. A fairly large ovarian ovum measures 1 mm. The fat-bodies are small with but three or four short digitations. The oviducts are well developed and highly convoluted. The pars recta is very short. The uteri open separately through bulging urinogenital papillæ into the cloacal lumen. Sections reveal that the inner lining wall of the uteri is produced into a number of small villilike folds. Furthermore, the appearance of the openings suggests that they had recently ruptured in preparation for spawning. Wolffian ducts have separate openings into the cloaca. The bilobed urinary bladder is large and somewhat thickish in the middle. (Text fig. 8B.)

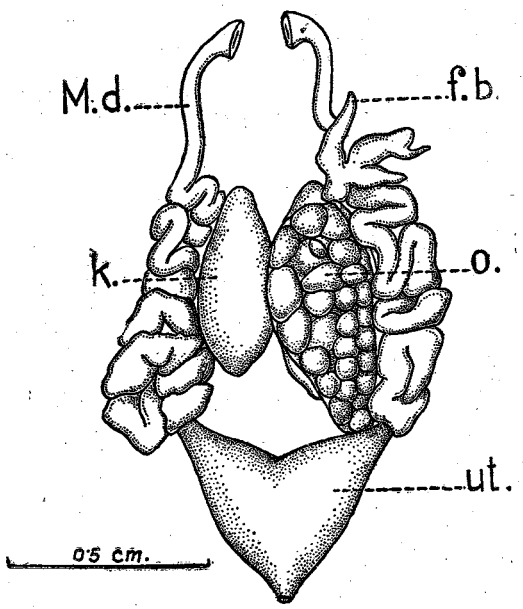
OREOPHRYNE ANNULATA (Stejneger).

Female.—Size: from snout to vent 22 mm (CNHM 5076, HH 751).

Locality and Habitat.—Mt. Apo, Meran, 6,000 feet, deep in end crack of small decaying log on ground, original forest,

Davao Province, Mindanao: Philippines, November 8, 1946 (*Harry Hoogstral*).

The asymmetrically placed kidneys are light brown, non-lobed, elliptical organs with both ends fairly pointed. The postero-mesial lobe is not apparent. The kidney measurements are: right, 4.3 × 1.8 mm, and left, 4.5 × 2 mm. The ovaries are symmetrical, thin-walled transparent simple sacs containing a small number of nonpigmented ova at various stages of their development. A large ovarian ovum is yellowish white



[Abbr.: *M.d.*, Müllerian duct; *k*, kidney; *f.b.*, fat-bodies; *o.*, ovary; *ut.*, uterus.]

FIG. 9. Diagrammatic ventral view of the origenital organs of a female *Oreophryne annulata* (the right ovary with fat-bodies not shown).

in color and measures 0.8 mm in diameter. The moderately developed fat-bodies consist of two or three digitations. The highly developed and glandular oviducts are creamy white in color. Pars recta is well distinguishable and is fairly long. The convoluted region has but a few coilings and gradually increases in diameter as it runs posterad, being maximum about 2.4 mm above the uterus. The large and extensive uteri with villose projections and some secretory mass inside their lumina, are united at their point of contact. The common uterus remains unopened within a large urinogenital papilla that

bulges into the cloacal lumen (Plate 5, fig. 29). The bulging papilla and the condition of the ovaries and the oviducts, however, suggest that an opening of the common uterus would soon be established. A terminal union for about 0.5 mm only characterizes the uneventful course of the Wolffian ducts. The urinary bladder is large and thin-walled. (Text fig. 9; Plate 5, fig. 28–29.)

DISCUSSION

The kidney.—The length-breadth ratio of the kidneys is variable. In the majority of the frogs and toads studied by Spengel (1876), Bhaduri (1953), and Bhaduri and Basu (1957), the kidneys are stated to be three to four times as long as they are broad. This may indeed be true, but there are always some aberrant species, in which the length is still greater. As for instance, in *Barbourula busuangensis* and *Rhacophorus otilophus* the length is four to five times the breadth, while in the female of *Ansonia muelleri* it is seven times the breadth. Spengel (1876) states that in *Cornufer vitianus* and *Philautus* the breadth is nearly half the length of the kidneys. The three species of *Cornufer* and a male of *Philautus,* also conform to the above statement. It may be concluded that "the length-breadth ratio does not seem to be a useful generic feature, though it may be specific" [Bhaduri (1953) 56].

The kidneys in general are not lobed except in *Bufo.* But Beddard (1907) has noted the kidneys to be broken up into 3 or 4 large, almost disconnected lobes in *Megophrys montana* and *M. nasuta* at least. They are slightly lobed in both sexes of *C. novæ-britannæ, Kaloula picta* and *Kalophrynus pleurostigma,* only in the females of *Megophrys monticola, Ooeidozyga laevis, C. meyeri* and *C. corrugatus,* and in the single male of *Rh. otilophus.* It is, however, remarkable that *A. muelleri,* though a near ally of *Bufo* does not possess the same sort of kidney lobe pattern.

In *K. picta* and *Kal. pleurostigma* the cylindrical longitudinal postero-mesial fold of the kidneys is very characteristic. Bhaduri (1953) has first drawn attention to this very peculiar but characteristic form of kidney fold in a microphylid species, *Uperodon globulosum,* which Devanesen (1912) casually mentioned in *U. systoma.* Bhaduri and Rudra (1944) have depicted in the diagram of the urinogenital organs of *Microhyla ornata* a similar fold in the kidney structure without

mentioning it in the text. Curiously enough, its confinement only to the left kidney of both sexes of the African microhylid, *Breviceps poweri* [Bhaduri and Mondal (1962)] and its complete absence in *Oreophyrne annulata* of the present study cannot be explained at present. Nevertheless, the presence and absence of such a kidney fold pattern in the microhylid genera seems interesting indeed. It may well be that this kidney fold is a generic feature, or it may even be the characteristic feature of the family Microhylidæ.

The shape of the kidney also varies considerably in different species and genera. In general, they are semilunar or broadly convex. The only special feature in the kidney shape is exhibited by *B. busuangensis, A. muelleri, Rh. otilophus,* and *Rh. longicrus.* In the male of *B. busuangensis* the kidneys are cone-shaped with the broad end directed anteriorly, while in the female they are divergent at the anterior end and have a completely different shape from those of the male. In the last three species the kidneys are provided with a narrow anterior and a broad posterior portion. This characteristic kidney shape has been pointed out by Hoffman (1932 and 1942) in *Chiromantis xerampelina,* by Bhaduri (1932) in *Rh. maximus,* and by Bhaduri and Basu (1957) in *Ch. rufescens.* In this connection, it may be pointed out that the kidneys in the three species of *Cornufer* have a much broader posterior end.

The testis.—The testes vary both in shape and in size, and these are, no doubt, related to the phase of the breeding cycle. Whether they constitute a characteristic feature of a species or genus cannot be vouchsafed by the present study.

The testes are in general, rounded to ovoidal in shape as found in all the species studied, although the elongated leptodactylid and bufonid types are not uncommon, as noted in *Ansonia muelleri, Kaloula picta,* and *Kalophrynus pleurostigma.*

The position of the testes in relation to the kidneys is also variable to a certain extent. They are in general situated at the anterior mesial border of the kidneys, but in *A. muelleri* and *Megophrys monticola* they are of enormous size, obscuring the entire kidneys from the ventral view. Bhaduri (1953) has pointed out that the position of testes may be a constant feature in some species and even in some genera, and this is indeed true for the genus *Cornufer.*

The testes are generally nonpigmented, but if pigment is present anywhere it is very slight, as in *A. muelleri.* Most pronounced pigmentation is, however, noticed in *Cornufer corrugatus.*

The testes are usually loosely held to the kidneys by the mesorchia through which pass a number of vasa efferentia. The number and arrangement of the vasa efferentia show extreme variation not only in the individuals of the same species but also in the same individual on either side. This has been shown by Sweet (1907), Hoffman (1942), Bhaduri (1953), and Bhaduri and Basu (1957).

Furthermore, attention may be directed to the North Bornean *Rhacophorus otilophus,* which seems to be an interesting species not merely in the possession of a huge testis but also in having the vasa efferentia arranged along its whole length, as in *Chiromantis* [Hoffman (1932 and 1942), Bhaduri and Basu (1957)].

Bidder's organ.—Bidder's organ which is the characteristic of the bufonids, represents a rudimentary ovary. It is held to be a universal feature of the genus *Bufo* and generally aborted in the adult females [Witschi (1933); Davis (1936)]. Davis (1936) noted Bidder's organ in *Ansonia muelleri.* Its absence in the female of this species, as recorded here, is due probably to its sexual maturity. It is also found in such other genera as *Nectophrynoides, Pedostibes* and *Pseudobufo,* which together with the genus *Bufo* constitute the family Bufonidæ [*sensu* Davis (1936)]. Noble's subfamily Bufoninæ is given the full family rank only to the presence of this characteristic structure [Davis (1936)]. It is only very recently that Griffiths (1954 and 1959) has recorded Bidder's organ in all extant genera of Atelopodidæ except *Brachycephalus,* and now considers this family as closely related to the Bufonidæ, being derived from it. Nevertheless, the significance of the occurrence of Bidder's organ in the two families is not well understood.

The ovary.—The shape, size and condition of the ovary in Salientia are variable depending upon the age, the sexual maturity of the specimen, and finally on the breeding phase.

The ovaries may be lobed or nonlobed and this has been thoroughly reviewed by Bhaduri (1953), who has drawn special attention to the fact that a number of genera and species may possess a simple saclike ovary without any ap-

parent lobes, and has given a list of them. Bhaduri and Basu (1957) have noticed the lobed condition of the ovaries in all the ranids studied by them. But a simple saclike ovary may be the characteristic feature for the terrestrially breeding ranid genus *Cornufer,* since it is found to occur in all three species. This type of ovary also characterizes the microhylid species, *Oreophryne annulata.* The remaining genera and species have been found to possess lobed ovaries. No comments are necessary on the number of lobes of ovary, since our observations are limited to examination of a single specimen of a species.

Noble (1927) states that the size of the ripe ovum is subject to great variation in the Salientia. According to Bhaduri [(1953) 58] the ovum size is proportionately larger in the simple saclike type of ovary. Thus, in *Cornufer* and *Oreophryne* mentioned above, the ova are found to be comparatively much larger in size than those in other species studied. Inger (1954) has given the egg-size of *Cornufer* to be above 3 mm in general, which is corroborated by the recent data presented by Alcala (1962) as also by us. He further gives the measurement of eggs of *annulata* in clutches which vary from 3 to 4 mm in diameter; including the capsules, they measure about 6 mm. However, Parker (1934) states the ovarian eggs to be large, each measuring 1.5 mm. The small dimension of the ovarian eggs (0.8 mm), as noted by us, must therefore be due to the immaturity of the ova. Thus, it lends further support to the above view of Bhaduri.

It has further been pointed out by Bhaduri (1953) that in some species the ova are relatively large, even in lobed ovaries, as in *Alytes* and *Heleophryne.* To this list *Barbourula busuangensis* may be added on the basis of the data of egg-size (5 to 5.5 mm) as provided by Inger (1954), though it is only 3.4 mm in the single specimen under the present investigation.

Inger (1954) has provided some data on the number of eggs laid by some species of Philippine Salientia. Thus, *Ansonia muelleri* lays about 300 eggs, each more than 2 mm in diameter, and *Kaloula picta* [Cendaña and Fermin (1940)] about 2,500 small eggs. The eggs of *Oreophryne annulata* are laid in small clusters; and three such clutches containing 3, 8, and 9 eggs have been found in moss covering tree trunks on Mount McKinley by the Philippine Expedition [Inger (1954) 447]. The egg-size varies from 3 to 4 mm in diameter, but including the capsule an egg measures about 6 mm.

The fat-bodies.—Bhaduri (1953) described the fat-bodies of different species of frogs and toads. They are indeed seasonal structures and show considerable variation in form. From the diagrams given by different authors it seems probable that in appearance and number of digitations some species may be said to have characteristic fat-bodies, and they are chiefly confined to small-sized species. Bhaduri and Basu (1957) have also mentioned this fact in their later studies on African Salientia.

No species of this investigation presents any characteristic pattern of fat-bodies except the males of *Cornufer corrugatus*, *Philautus longicrus*, and *Kalophrynus pleurostigma*. Of these species, the fat-bodies are small and knoblike in *Philautus*, while those in *C. corrugatus* consist of two or three small flattened digitations. In *Kalophrynus pleurostigma* they are very narrow and ribbon-shaped.

The Wolffian duct.—It has been noted by Bhaduri (1953) that the Wolffian ducts show some remarkable modifications in the Salientia, especially, in their terminal openings into the cloaca, and in providing a seminal vesicle in the male of some species.

Except some casual observations on the terminal union of the Wolffian ducts in the males of *Xenopus lævis* [Gilchrist and von Bonde (1922)] and *Bufo melanostictus* [Koch (1934)], nobody prior to Bhaduri and Banerjee (1939) and Bhaduri (1953) seem to have paid any particular attention to the actual nature of the openings of the Wolffian ducts into the cloaca. On the other hand, all authors seemed to have accepted the general dictum of Spengel (1876) that the separate openings of the Wolffian ducts are the rule in the Salientia. Bhaduri (1953) has, however, shown in contradiction to Spengel's view that in a number of genera and species a terminal union of the Wolffian ducts is as common a feature as the separate openings.

Spengel (1876) observed separate openings of the Wolffian ducts in *Cornufer vitianus*. The present investigation shows that of the family Ranidæ, all the species of *Cornufer*, together with two other species; namely, *Staurois natator* and *Ooeidozyga lævis* have separate openings of the Wolffian ducts. It seems quite likely therefore, that separate openings of the ducts are present in all the genera and species of the family Ranidæ, and their fusion as noted in a female of *Rana*

(*Aubria*) *subsigillata* [Bhaduri and Basu (1957)] and *Phrynobatrachus minutus* (Bhaduri and Banerjee in MS.) may be viewed for the present as isolated cases. So far as the Discoglossidæ is concerned, previous works [von Wittich (1853); Spengel (1876)] on *Alytes, Bombina* and *Discoglossus,* together with a male of *Barbourula busuangensis* of the present investigation show separate openings of the Wolffian ducts into the cloaca, though a female of the latter species has a trivial terminal union.

In the family Pelobatidæ the separate openings of the Wolffian ducts are the general rule, and this has been shown by Spengel (1876) in *Pelodytes fuscus, Pelodytes punctatus* and *Megophrys montana,* and by Bhaduri (1953) in *Scaphiopus couchi* and *S. holbrooki.* Special attention is, however, directed to the fact that of the two species of *Scaphiopus* studied by Bhaduri a terminal union of the Wolffian ducts has been noted in the female only of *S. holbrooki.* He attributes this terminal union also to the female of *Megophrys parva* which he studied. But observations on *M. monticola* show clearly that the ducts are separate in both the sexes. Since these terminal unions are confined to the females only as reported, the findings become interesting indeed. Only further studies on both the sexes of different species of the extant genera of Pelobatidæ; namely, *Megophrys, Nesobia, Scutiger, Aelurophryne, Leptobrachella, Ophryophryne* of the subfamily Megophryinæ, *Pelobates, Pelodytes* and *Scaphiopus* of the Pelobatinæ, and *Nesomantis* and *Sooglossus* of the Sooglossinæ, will give us an understanding of the true anatomical nature of openings of the Wolffian ducts into the cloaca.

In the family Bufonidæ, Bhaduri (1953) has shown a united Wolffian duct in all the males of the different species of *Bufo* except *boreas.* It is, however, interesting to note that *Ansonia muelleri* of the present investigation, which may be said to be a nearest ally of *Bufo,* possesses separate openings of the Wolffian ducts. These observations tend to show that the posterior endings of the Wolffian ducts in these two closely allied genera may well be in a state of evolutionary flux, as suggested by Bhaduri (1953) for the genus *Bufo.*

In all rhacophorids so far studied the Wolffian ducts have separate openings as are usual in the ranids.

A terminal union of the Wolffian ducts has, however, not been recorded previously in the microhylids. It is, there-

fore, of interest to note a pronounced union of these ducts in a female *Oreophryne annulata*. In *Kaloula picta* and *Kalophrynus pleurostigma* the openings of the Wolffian ducts remain, however, separate.

a. The vesicula seminalis: Bhaduri (1953) has pointed out that the vesicula seminalis is very variable in the Salientia. Two types of vesicula seminalis have so far been recorded in ranid frogs, namely: (*i*) a simple bottlelike or spindle-shaped dilatation, and (*ii*) a complex-chambered structure at the free posterior region of the Wolffian ducts behind the kidneys. Both these types have been reported previously by different workers like Spengel (1876), Boulenger (1896), Gaupp (1904), Holmes (1927), Noble (1931), Witschi (1933), Koch (1934), Bhaduri and Banerjee (1939), Rugh (1941 and 1951), Bhaduri (1953), Bhaduri and Basu (1957), Griffiths (1959), Bhaduri and Banerjee (in MS.), and Bhaduri and Mondal (1962) in a number of genera and species.

So far as the Philippine Salientia are concerned, the three ranid genera have the two types of vesicula seminalis. It appears from the conditions prevalent in *Cornufer* and *Ooeidozyga lævis* a spindle-shaped vesicula seminalis may be held as the usual characteristic feature. Bhaduri (1953) has recorded a complex-chambered *Rana temporaria*-like vesicula seminalis in the African ranid frog, *Phrynobatrachus kinangopensis*. Bhaduri and Basu (1957), and Bhaduri and Banerjee (in MS) have further recorded a similar type of vesicula seminalis in a few other species of *Phrynobatrachus*, and later they (Bhaduri and Banerjee in MS.) attempted a division among the various species of this genus on the basis of the two types of vesicula seminalis. The present study reveals a complex-chambered type of vesicula seminalis, as in *R. temporaria*, in a hill-stream adapted ranid frog, *Staurois natator* (Plate 3, fig. 12).

Of the remaining Philippine species studied, the following; namely, *Megophrys monticola, Ansonia muelleri, Kaloula picta,* and *Kalophrynus pleurostigma* possess a spindle-shaped vesicula seminalis which characterizes the genus *Bufo* [vide Witschi (1933); Koch (1934); Bhaduri and Banerjee (1939); Bhaduri (1953)], and since *Ansonia* is a directly derived genus or a close ally of *Bufo*, it is likely that the species of *Ansonia* should also possess this spindle-shaped type of vesicula seminalis.

The prominent bottlelike seminal vesicle of *Philautus longicrus* may be compared with the characteristic type of seminal vesicles of *Eleutherodactylus* [Bhaduri (1953)] and *Sminthillus* [Griffiths (1959)].

In the male of *Rhacophorus otilophus* the Wolffian duct lying lateral to the kidney is the most remarkable feature, as in *Rhacophorus* [Bhaduri (1932 and 1953] and *Chiromantis* [Hoffman (1932, 1942, and 1943); Bhaduri and Basu (1957)] and the disposition-pattern is comparable with that of *Rh. maximus* [Bhaduri (1932)], *Chiromantis xerampelina* [Hoffman (1932, 1942, and 1943)], and *C. rufescens* [Bhaduri and Basu (1957)]. The prominent large villose projections within the Wolffian duct in this region as well as in the fairly dilated posterior region behind the kidneys tend to indicate their glandular nature. The photomicrographs provided by Bhaduri (1932) of the free portion of the Wolffian duct of *Rh. maximus* do not show any villose projection. Bhaduri and Basu (1957) hold that the glandular portion is confined to the anterior coiled region of the Wolffian duct which may not be true, since a glandular villose wall is observed even in the free portion of the Wolffian duct (Plate 4, figs. 20–21.) in *Rh. otilophus* of the present study.

b. The urinogenital sinus: The urinogenital sinus, though not observed in any of the species of the present investigation, appears, however, from the previous reports [de Villiers (1934); Bhaduri and Rudra (1944); Bhaduri (1953); Bhaduri and Basu (1957); Basu (1960); Bhaduri and Banerjee in MS.] to be a highly interesting structure in the salientians.

THE MÜLLERIAN DUCT

In the male.—Müllerian ducts occur frequently in various forms of development in the males of Salientia. A critical review of the Müllerian duct has been given by Spengel (1876), Eggert (1926), and very recently by Bhaduri (1953).

In the present investigation on Philippine amphibians, Müllerian ducts have been recorded in *Barbourula busuangensis* and *Cornufer corrugatus* only. In the rest of the species Müllerian ducts are, however, absent. It is indeed interesting to note that this duct persists in such discoglossid genera as *Alytes* [Spengel (1876); Boulenger (1896); Gadow (1901); Boonacker (1927)], *Bombina* [Leydig (1853); von Wittich (1853); Spengel (1876)], and *Discoglossus* [Leydig (1853);

Von Wittich (1853); Spengel (1876); Gadow (1901)]. *Barbourula* also shares this characteristic feature like other discoglossid genera. This may indicate a close phylogenetic relationship among the different genera of the family Discoglossidæ. Spengel (1876) has not observed any Müllerian duct in *Cornufer* (= *Platymantis*), but among the three species of the present investigation it occurs in *Cornufer corrugatus*. Regarding *Philautus*, we agree with Spengel's observations that they are totally absent.

Witschi (1933) holds the view that in *Bufo* there is some relationship between Bidder's organ and the persistence of Müllerian ducts in some form of development, to which Horie (1938) concurs. Spengel (1876), Koch (1934), and Bhaduri (1953) have shown that the Müllerian ducts are present in all species of *Bufo*, except *B. quercicus* [Witschi (1933); Bhaduri (1953)]. Bhaduri [(1953) 68] writes, "while it may be true for certain species of *Bufo*, it is not true for other genera, since the ducts have been reported from widely different genera without Bidder's organ. Probably *B. quercicus* may be cited as an example which breaks this seeming relationship totally." To this exception may be added *Ansonia muelleri*, a close ally of *Bufo*, which though possesses a moderately developed Bidder's organ has no Müllerian ducts, however.

In the female.—The Müllerian duct in the female of Salientia is the oviduct, of which a general account has been given by Spengel (1876), and recently a comprehensive review has been made by Bhaduri (1953). In young and immature individuals it is more or less a straight tube, but in the adult it is extraordinarily coiled, most markedly so during the breeding season. From the morphological and histological standpoint, it is divisible into three regions: a straight *pars recta*, a much coiled middle part, the *pars convoluta*, and a dilated posterior portion, the so-called *uterus*. Bhaduri (1953) has shown some characteristic modifications of the different sections of the oviduct.

In the present study a very short pars recta is observed in all the species except *Ansonia muelleri* and *Oreophryne annulata*, where it is a trifle longer. In *Kaloula picta*, however, it appears to be almost absent.

The pars convoluta is characteristic in such forms as *Cornufer*, *Ansonia*, and *Oreophryne*. In *Cornufer*, a marked demarcation could be made out between the anterior and the posterior portions of the pars convoluta, the latter having the

major convolutions. In *A. muelleri* the pars convoluta has but a few uniformly distributed coilings. In *O. annulata,* it is less coiled, but increases enormously in diameter in its course posterad, being maximum in the region above the uteri.

a. The uterus.—Bhaduri (1953) has suggested a scheme of classification of the uterine condition in the Salientia. In main, it falls into three broad groupings; namely, (*1*) 'The *uterus separatus* group' where the two uteri are independent and open separately into the cloaca, (*2*) 'The *uterus communis* group'—a confluence of the two uteri into an unpaired common chamber without having any partition wall, and (*3*) 'The *uterus septatus* group' having an incomplete coalescence of the uteri with a partition wall running antero-posteriorly between the two uteri.

According to the schematic groupings of Bhaduri *Ooeidozyga lævis, Kaloula picta,* and *Kalophrynus pleurostigma* may be placed in the *uterus separatus* group. The rest of the species show a united uteri. Of these, *Barbourula busuangensis, Megophrys monticola, Ansonia muelleri,* and *Oreophryne annulata* are to be placed in the *uterus communis* group; and the rest of the species; namely, *Cornufer* spp. and *Staurois natator* belong to the *uterus septatus* group.

In the family Discoglossidæ, both the conditions of the uterus have been reported by Spengel (1876); namely, separate in the genus *Discoglossus* and united in both *Alytes* and *Bombina,* although the nature of union is not clear. *Barbourula* belongs to the later group, but is remarkable in having the union of the uteri at their point of contact and it may be placed in the *uterus communis* group of Bhaduri (1953).

A *communis* type has also been noticed in a pelobatid frog, *M. monticola,* though Bhaduri (1953) has observed a short partition wall hanging between the uteri in another species, *M. parva. Ansonia muelleri* which is an ally of *Bufo* stands out unique in having a *communis* type of uterus (*vide infra*). Furthermore, in the family Microhylidæ, Bhaduri and Mondal (1962) have for the first time reported a *communis* type of uterus in *Breviceps poweri.* To this list may now be added another microhylid, *Oreophryne annulata* from the present study.

Not content with the study of union of the uteri in different species of frogs and toads Bhaduri (1953) discusses the variation in the degree of their union, and states that "it possibly may be of functional or evolutionary significance." He has

further classified the septatus condition into four main types depending upon the extent of union of the uteri. Previous workers, and recently Bhaduri and Basu (1957) have recorded separate uteri (*'Uterus separatus'* type) in all the species of Ranidæ except in *Rana* (*Aubria*) *subsigillata* and *Cacosternum boettgeri*. The two ranid genera; namely, *Staurois* and *Cornufer* show septatus condition of the uteri, as revealed in the present study. The trivial terminal union of the uteri for about a millimeter in *S. natator* may fit in with the *Gastrothecan* type of uteri described by Bhaduri [(1953) 64]. The terminal union of the uteri of *S. natator*, trivial though it may be, warants further study. On the other hand, owing to the possession of a very short partition wall between the uteri in all the three species of the other ranid genus, *Cornufer*, much difficulty is experienced in placing this genus into any of the *Septatus* types described by Bhaduri [(1953) 64]. This seems to be an extreme adaptive specialization in the Ranidæ perhaps owing to the large egg-size.

b. The uterine opening into the cloaca.—It has been stated by earlier authors that in the Salientia, the uterine aperture into the cloaca is established comparatively late in life, generally at the time when the females attain sexual maturity. But it is interesting to note that no author prior to Bhaduri seems to have thrown any light on the actual fate of the uterine opening into the cloaca before, during and after breeding.

Bhaduri (1946 and 1953) has shown that there occurs an occlusion or closing of the uterine aperture after spawning into the cloaca in the three species of unrelated genera; namely, *Eleutherodactylus nubicola, Leptodactylus pentadactylus*, and *Gastrotheca boliviana griswoldi*. Bhaduri and Basu (1957) and Bhaduri and Banerjee (in MS) have lent further support from their studies on African Salientia. After reviewing the uterine openings into the cloaca Bhaduri [(1953) 66] states, "The general conclusion is that the Müllerian ducts open into the cloaca at the onset of the breeding phase, remain patent till spawning is over, and then close again. The exact time and method of opening and closure cannot be predicted from these studies. But from the cases of *Gastrotheca* and *Eleutherodactylus* it appears that the opening closes soon after oviposition." With a view to reinforcing the above view he further draws an analogous condition in a fish [*vide* Bhaduri (1946)] and this raises the fundamental question of a sexual cycle in all lower vertebrates.

In the present investigation, we have observed openings of the uteri in *Barbourula busuangensis, Ooeidozyga lævis, Staurois natator, Cornufer corrugatus, Kaloula picta* and *Kalophrynus pleurostigma,* and each one of them is held to be sexually mature in view of the well-developed oviducts and ripe ova in the ovaries.

The uteri are found to remain unopened in the rest of the five species studied. It may, however, be noted that in *C. novæ-britannæ* although the oviducts and ovaries look ill-developed, the bulging uterine papilla tends to indicate its attainment of sexual maturity for the first time. In the other four species, well-developed condition of the ovaries and the oviducts suggest that an opening would sooner or later be established in preparation for spawning.

The specimen of *C. corrugatus* shows that its uterine opening into the cloaca is probably on the verge of closure after spawning, since the ovaries are spent and the oviducts are highly developed and glandular.

THE URINOGENITAL ORGANS AND BREEDING HABITS

It may now be held to be established that there is a correlation between the structural modifications of the urinogenital organs and the breeding habits of frogs and toads, especially of those which breed outside water.

Most of the Philippine salientians lay their eggs in water, and this element is necessary for their development, unless they have evolved some specialized protection against drying of eggs. However, there are some frogs that are terrestrial breeders and therefore, they lay their eggs outside water either on the ground, or in holes in the ground, or on vegetation.

Cornufer has been separated from the genus *Rana* by its terrestrial breeding habits and direct development [Noble (1927)], in addition to certain other morphological characters. All the members of *Cornufer* are typically inhabitants of the forest floor and deposit a few large, nonpigmented eggs under débris and in crevices and holes in plants [Inger (1954) 197, 348; and Alcala (1962)]. In consequence of their terrestrial breeding habits, the main adaptive changes are shown by the females in the possession of saclike ovaries containing a few large nonpigmented eggs and united uteri. However, the absence of any modification in the Wolffian ducts of the males into any special type of seminal vesicle may be readily explained

for the discharge of not much quantity of seminal fluid for the fertilization of the reduced number of eggs which *Cornufer* usually lays.

The treefrogs of the genera *Rhacophorus* and *Philautus* present further interesting examples of terrestrial breeding habits. They are the only two genera of the treefrogs in the southern Asia that prepare foam nest outside water [Noble (1927) 112]. To this has been added the African rhacophorid frogs, *Chiromantis* for similar breeding habits. These treefrogs especially those of *Rhacophorus* have been described to have aerial nesting sites and the foamy egg masses are usually attached to vegetation of some herbaceous plants or to the branches of low trees growing beside stagnant pools or slow-moving streams.

No information is available from Inger's (1954) account about the breeding habits of *Philautus*. The breeding habits of only two species of this genus that are so far known, are those of *P.* (= *Ixalus*) *horridus* [Boulenger (1912)] and *P. vittatus* [Smith (1924); Pope (1931)]. Smith writes about *P. vittatus*, 'It frequents low bushes by the side of ponds, and makes a round frothy "nest" similar to that made by the common treefrog *Rhacophorus leucomystax* (Gravenh.). This is attached to some bough overhanging the pool and the larvæ as they hatch, are washed out of it by the rain, and dropping into the water below continue their development in the usual manner'. Pope [(1931) 585] describes in fair detail the froth nesting habit of breeding of this frog at Hainan, which he observed in 1923 during the months of June and July. He found numerous egg masses containing white eggs which were deposited just above the water on different kinds of leaves. Regarding *P.* (= *Ixalus*) *horridus* Boulenger [1912) 257] writes that the frogs deposit their pigmentless eggs on the tree trunk in frothy masses about the size of a cricket-ball, a foot or two above the surface of the water in some water-filled cavities. The eggs are washed down by the rain within three or four days, otherwise the froth dries up and the eggs perish. He considers this froth nesting habit of this species identical to that of *Rhacophorus leprosus*. Since the froth making habit of breeding of *Chiromantis* and *Rhacophorus* is very peculiar and well known, and *Philautus* being a closely derived genus or a near ally of *Rhacophorus*, it can be presumed that the species of *Philautus* practise also the same sort of terrestrial

breeding habit as *Rhacophorus*. Thus Noble's (1927) deduction about the breeding habits of *Philautus* may seem justified. Following him, we can safely attribute the foam building habit to the Philippine species, *P. longicrus*.

Bhaduri (1932 and 1953), Bhaduri and Basu (1957), and Hoffman (1932, 1942, and 1943) have dealt with in fair detail the remarkable modification of the Wolffian ducts lateral to the kidneys in males of *Rhacophorus* and *Chiromantis*, and have also correlated these modifications with their peculiar breeding habits. *Rh. otilophus*, which prepares froth nest of eggs [Inger (1956) 415] shows the same type of modification as found in *Rh. maximus* [Bhaduri (1932)], *Chiromantis xerampelina* (Hoffman), and *Ch. rufescens* [Bhaduri and Basu (1957)] in all essential respects. Furthermore, the fairly dilated and glandular, free posterior portion of the Wolffian ducts behind the kidneys, as noted in this species may also contribute to the formation of the froth nest. However, it is worth noting that such a characteristic rhacophorid type of modification of the Wolffian ducts is absent in the male *P. longicrus*. The bottle-like dilatation of the Wolffian ducts behind the kidneys as is apparent in this species may well be compared with that found in *Eleutherodactylus* [Bhaduri (1953)] and *Sminthillus* [Griffiths (1959)]. Such a remarkable modification of the Wolffian ducts makes it highly probable that their glandular villose walls provide a secretion with which the sperms are discharged over the eggs during amplexus. This may again be a contributory factor to the preparation of the froth nest. It may, however, be pointed out here, in passing, that there is an apparent parallelism between rhacophorids and leptodactylids in building foam nests of eggs [*vide* Noble (1931); Parker (1940); Breder (1946)]. Noble [(1931) 282] writes that the foam nest builders are said to produce an extra gelatinous nest material before the eggs are laid. Bhaduri (1953) has shown that in *Leptodactylus* the posterior part of pars convoluta is greatly modified in such a manner as to produce the extra gelatinous material, and this may be correlated with the foam nest building habit of these frogs. If we surmise such a modification, it should also be present in the females of rhacophorid frogs. This idea may get support from the fact that the females of *Rh. leucomystax* and *Rh. bambusicola* have been reported by Pope (1931) and Liu (1950) respectively to produce foam nests of eggs without the help of their male partners. In

view of the above, a fresh examination of the oviducts of females of rhacophorid frogs is necessary for the purpose of correlating structural modifications with breeding habits, since a broad hint has already been given by Bhaduri and Basu [(1957) 48] in connection with their studies on *Ch. rufescens*. They state: "we wish to draw attention to the pronounced dilatation of the pars convoluta portion of the Müllerian ducts anterior to the uterus. Hoffman has not studied any female specimen of *Chiromantis;* nor has Bhaduri shown any such modification of the pars convoluta in the female *Rhacophorus* he has studied. We are not sure whether this modification could also be correlated with the froth-making habits of *Chiromantis*. It would be worth studying in the living animals, if that were possible."

Oreoprhyne, though a microhylid is also a terrestrial breeder [*vide* Parker (1934) 7–8, 168; Inger (1954)] and its eggs undergo direct development [Noble (1927) 114–116]. Inger [(1954) 447] writes: "The eggs of *annulata* are laid in small clusters. Three such clutches, found in moss covering tree trunks on Mount McKinley by the Philippine Expedition, contain three, eight, and nine eggs, respectively. The eggs vary from 3 to 4 mm in diameter; including the capsules, they measure about 6 mm." From the above, it may be held that this species lays a fewer number of eggs which are large. The only single female individual of this species shows a *communis* type of uteri which may be correlated with the large size of eggs. The rest of the Philippine species, are aquatic breeders.

Barbourula busuangensis is a thoroughly aquatic discoglossid frog which is adapted to streams with moderate currents. Inger [(1954) 212] writes: "The eggs of *busuangensis* are large, few in number, and almost lacking in pigment. A female (89.7 mm snout to vent) contained a total of 78 ripe ova. Ten of the latter varied in diameter between 5.5 and 6 mm, with a mean of 5.9 mm. A possible explanation for the loss of pigment may be that the ova are placed under rocks in streams. This habit would make dark pigment functionless and would tend to release the eggs from the selection pressure that maintains the pigment in other aquatic frog ova." From the above it may be held that *B. busuangensis* deposits a fewer number of eggs which are relatively large. It is likely that the species in which ovum-size is comparatively larger, possess a fusion type of uteri (*Septatus* and *Communis*),

and this has been shown by Bhaduri (1953), Bhaduri and Basu (1957), and Bhaduri and Mondal (1962) in a number of genera and species. *Barbourula* conforms to this pattern and according to Bhaduri's schematic representation *B. busuangensis* falls within the *communis* group.

The only two species of the present investigation that are known to breed in and along swift, rocky mountain streams of the Philippines belong to the genera *Ansonia* and *Staurois*. Recent herpetologists have separated *Ansonia* from *Bufo* on the characteristics of their larval histories and large ovum-size [Inger (1960)], just as *Staurois* has been separated from *Rana* on similar grounds. In contrasting *Ansonia* with *Bufo* Inger [(1954) 239–240] states: "the species of *Bufo* usually have broods that number in the thousands, with rare exceptions (in the smallest species) of over five hundred. Also the eggs have a maximum diameter of 2 mm even including those of the giant species *marinus*.

Contrasting sharply with this picture, the females of *Ansonia penangensis* and *Ansonia muelleri* lay large nonpigmented eggs (average diameter over 2 mm) in relatively small number." In *A. muelleri* the main adaptive changes are, however, shown by the females in the possession of a *communis* type of uteri which is a necessary corollary of the large ovum size.

In describing the process of egg laying of *Staurois chunganensis* Liu [(1950) 59] writes: "The method of egg-laying, the nature of the egg-mass, and the type of egg are especially adapted to breeding in swift water. The attachment of the eggs to the underside of the stones in the water is functional in keeping the eggs from being washed downstream. The small amount of jelly also reduces the resistance to the current. The white color of the eggs of *S. chunganensis* is not clearly adaptive; the egg color is unknown for other species of *Staurois*." Although no information is available from Inger's account (1954) about the breeding habit of *S. natator*, it may be held from the above statement that it also practises the same sort of breeding as *S. chunganensis*. Liu (1950) does not impose any adaptive significance to the white eggs of *S. chunganensis*, but it may, however, be pointed out that the loss of pigments from the eggs of *S. natator* and *A. muelleri* may be due to the fact that these species possibly deposit their eggs on the undersurface of the stones in the streams away from light, and as such pigment would have no value. Inger [(1954)

212] offers such an explanation for *Barbourula busuangensis* which also possess nonpigmented eggs.

The rest of the Philippine species; namely, *Megophrys monticola, Ooeidozyga lævis, Kaloula picta,* and *Kalophrynus pleurostigma* have no breeding peculiarity which would require any comments for correlation with the urinogenital structures. They breed, like ordinary *Rana,* in common aquatic situations. Inger [(1954) 419] writes about *Kal. pleurostigma* that "shallow temporary pools of rain water are selected as breeding sites by this species. On Mount McKinley *pleurostigma* was observed breeding in rain-filled road ruts." On the other hand, Cendaña and Fermin (1940) describe the breeding habits of *K. picta,* which they observed at Los Baños, Luzon. According to them, this species always oviposits in pools of rain water, at least in the vicinity of Los Baños. Females with mature eggs are to be found every month of the year and egg masses every month but March, April, and early part of May, the driest period of the year at Los Baños. The peak of the breeding season falls between July and October, coinciding with the heaviest rainfall. They further noted the number of eggs laid by twenty individual females varied from 812 to 4,029, with a mean of $2,250 \pm 161.25$. Except for the union of uteri in *M. monticola* which may be due to fairly large ovum size, in all these species the urinogenital structures are in essential respects so similar to those of ordinary *Rana* that no comment is necessary.

CONCLUDING REMARKS

For a better understanding of the peculiarities of the urinogenital organs of the salientians which have been described and dicussed above, Table 1 is annexed here, showing the fate of Wolffian ducts and uteri, together with other associated peculiarities.

It is apparent from the table that none of the members of the six families shows a united Wolffian duct, except the single female individuals of both *Barbourula busuangensis* and *Oreophryne annulata,* where a terminal union of these ducts has been observed. Among rhacophorids, *Rhacophorus* and *Chiromantis* possess more or less a similar specialized type of Wolffian ducts whereas *Philautus* possesses a pronounced bottle-shaped seminal vesicle. On the basis of this difference in the structure of seminal vesicles *Philautus* stands apart from

TABLE 1.—*The fate of Wolffian ducts and uteri, together with other associated peculiarities.*

Families and species	Sex	Wolffian duct	Uterus	Further peculiarity, if any
Discoglossidæ				
Barbourula busuangensis	♂	Separate		Presence of the Müllerian duct
Do	♀	United (terminally)	United (*Communis*)	
Pelobatidæ				
Megophrys monticola	♂	Separate		
Do	♀	do	do	
Bufonidæ				
Ansonia muelleri	♂	Separate		Presence of Bidder's organ, but no Mullerian duct.
Do	♀	do	do	
Ranidæ				
Aleidozyga laevis	♂	Separate		
Do	♀	do	Separate	
Staurois natator	♂	Separate		Presence of complex-chambered seminal vesicle.
Do	♀	do	*Septatus* (terminally united).	
Cornufer meyeri	♂	Separate		Presence of spindle-shaped seminal vesicle.
Do	♀	do	United (*Septatus*)	
C. corrugatus	♂	Separate		Presence of the Müllerian duct and a spindle-shaped seminal vesicle.
Do	♀	do	do	
C. novæ-britanniæ	♂	Separate		Presence of spindle-shaped seminal vesicle.
Do	♀	do	do	
Rhacophoridæ				
Rhacophorus otilophus	♂	Separate		Modified Wolffian duct lateral to the kidney.
Philautus longicrus	♂	Separate		Presence of bottle-shape seminal vesicle.
Microhylidæ				
Kaloula picta	♂	Separate		Incipient postero-mesial fold in the kidneys.
Do	♀	do	Separate	do.
Kalophrynus pleurostigma	♂	Separate		Prominent cylindrica !postero-mesial fold in the kidneys.
Do	♀	do	do	do.
Oreophryne annulata	♀	United (terminally)	United (*Communis*)	

Rhacophorus, although both are said to possess similar breeding habits. The question of separation of *Philautus* from *Rhacophorus* needs further study in view of the meager distinction between absence and presence of vomerine teeth [Smith (1930) 115; Inger (1954) 393–395; and Alcala (1962) 724]. *Philautus* is, however, rich in species and unless a number of species are anatomically investigated from the viewpoint of urinogenital organization and their breeding habits, recognition of the two genera will perhaps remain in a fluid state.

The peculiarities that have been associated with the uteri are whether they are separate or united, and this difference has been mainly due to large ova-size, irrespective of the genera to which they belong.

Inger (1954) has discussed in length the taxonomic background of Philippine frogs and toads. The anatomical features thus considered, may have some taxonomic importance for each species dealt with by him, and in some instances they may even lend support to generic separation, as for instances, *Cornufer*, and possibly *Staurois* from *Rana*, and *Ansonia* from *Bufo*. *Kaloula* and *Kalophrynus* show natural relationships in their urinogenital organization, but *Oreophryne*, though only a female specimen has been studied here, stands quite apart from them in the absence of any fold in the kidneys and in having a *communis* type of uteri.

Furthermore, Alcala (1962) has considered egg-size and number of eggs laid in clutch to be correlated with the evolution of direct development. This may not, however, be always true, since direct development on land may have taken place in a linear fashion within a genus but in diverse ways in different families. This, therefore, does not unequivocally establish an intergeneric relationship, let alone the interfamilial relationship.

Bhaduri and Basu [(1957) 51] have stated: "The facts of internal morphology indeed should also explain phylogenetic relationships, but the characteristics of one system alone, as we have presented here in our studies, may not be of great help in straightening out the difficulties and differences of systematists." To this may be added what Inger [(1954) 201] has nevertheless concluded: "Thus, if every genus is characterized by an assemblage of morphological features contributing to an adaptive pattern that can be shown to have fundamental ecological significance, the genera will coincide

with natural groups and many of our present difficulties will disappear."

SUMMARY

1. The urinogenital organs of thirteen species belonging to eleven genera of six families of Salientia are described, in all the species and in nine of the genera for the first time. Except *Cornufer novæ-britannæ* and *Rhacophorus otilophus*, the rest of the species were collected from the various parts of the Philippines.

2. The general structural pattern of the kidneys is more or less constant in all the species, although there may be subtle difference regarding their particular shape, size, length-breadth relation and position. The characteristic kidney pattern of *Barbourula, Cornufer, Ansonia muelleri, Rhacophorus otilophus, Philautus longicrus, Kaloula picta,* and *Kalophrynus pleurostigma* is emphasized.

3. The testes are variable in shape and size, and also in position relative to the kidneys. The huge size of the testes of *Megophrys monticola, Ansonia muelleri,* and *Rhacophorus otilophus* is discussed.

4. Bidder's organ is present in *Ansonia muelleri.*

5. The variation in the number of ovarian lobes is discussed. All the species of *Cornufer* and a microhylid species *Oreoprhyne annulata* are shown for the first time to possess a simple saclike ovary in which the ovum size is relatively large.

6. The inter-relations of the urinogential ducts of all the species towards the posterior part of the cloaca are investigated by stained serial transverse sections.

7. Various modifications of the Wolffian ducts are discussed. It is shown that they are terminally united in the females of *Barbourula busuangensis* and *Oreophryne annulata,* and its significance is discussed.

8. Morphological variation of the vesicula seminalis is discussed; and a complex-chambered *Rana temporaria* type of seminal vesicle is recorded in *Staurois natator.*

9. The site of production of the secretory mass that fills the Wolffian ducts of the male *Rhacophorus otilophus* and *Philautus longicrus* is discussed.

10. A urinogenital sinus is recorded in none of the species of the present investigation.

11. The uteri remain separate in most Salientia, but united uteri have been recorded in six genera of which five are here

recorded for the first time. Although the *uterus septatus* type is recorded in two ranid genera; namely, *Staurois natator* and *Cornufer*, much difficulty is experienced in placing the latter genus into any of the *septatus* types described by Bhaduri (1953).

12. The opening and occlusion of the uterine apertures into the cloaca in relation to the breeding phase are discussed.

13. Among the different species, rudimentary Müllerian ducts are recorded only in the males of *Barbourula busuangensis* and *Cornufer corrugatus*.

14. A table is included, showing some important features of the urinogenital organs and the course and fate of the urinogenital ducts of the species under the present investigation.

15. The significance of the various peculiarities of the different anatomical characters of the urinogenital system on the systematics of some Salientia is discussed.

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ILLUSTRATIONS

PLATE 1

[Photomicrographs from a series of transverse sections passing through the kidney region (fig. 1) and of the gut with the urinogenital ducts behind the kidney (figs. 2–5).]

DISCOGLOSSIDÆ

Barbourula busuangensis Taylor and Noble

MALE

FIG. 1. The convoluted region of the Müllerian duct in the anterior region of the kidney. Note the glandular secretion inside the duct, × 62.

2. The separate openings of the Wolffian ducts into the cloaca; the left has already opened and the right is about to open, × 45.

FEMALE

3. The common uterus and the separate Wolffian ducts behind the kidneys, × 45.

4. The union of Wolffian ducts in the cloacal wall; the common uterus opening through the uterine papilla into the cloaca, × 56.

PELOBATIDÆ

Megophrys monticola stejnegeri Taylor.

MALE

5. The separate openings of the Wolffian ducts into the cloaca; the right has already opened and the left is on the verge of opening, × 62.

PLATE 2

[Photomicrographs from a series of transverse sections passing through the posterior region of the gut with the urinogenital ducts behind the kidneys.]

Megophrys monticola stejnegeri Taylor

FEMALE

FIG. 6. The common uterus and the separate Wolffian ducts lying immediately above the cloacal wall, × 45.

7. The separate Wolffian ducts lying below the uterine papilla in the cloacal wall, × 45.

BUFONIDÆ

Ansonia muelleri Boulenger

MALE

8. The Wolffian ducts open separately into the cloaca, × 74.

FEMALE

9. The common uterus and the separate Wolffian ducts lying against the cloacal wall, × 56.

10. (0.22 mm after fig. 9). The common uterus is pushed inside the cloaca forming a uterine papilla, with the Wolffian ducts

lying against it. The urinary bladder is prior to opening into the cloaca, × 56.

RANIDÆ

Ooeidozyga lævis lævis Günther

FEMALE

11. The two uteri open separately through the uterine papillæ into the cloaca. The Wolffian ducts remain separate, × 56.

PLATE 3

[Photomicrographs from a series of transverse sections passing through the kidney region (fig. 12) and of the gut with the urinogenital ducts behind the kidney (figs. 13–17).]

Staurois natator Günther

MALE

FIG. 12. The Wolffian duct with the complex-chambered seminal vesicle at the posterior region of the kidney, × 56.

FEMALE

13. The common uterus is pushed inside the cloacal lumen, with the Wolffian ducts still lying above it, × 45.

Cornufer meyeri Günther

FEMALE

14. The common uterus with the separate Wolffian ducts lying closely juxtaposed behind the kidneys, × 24.
15. The common uterus forms a bulging papilla inside the cloacal lumen. The Wolffian ducts lie against cloacal wall, being separated by a common partition wall, × 24.

Cornufer corrugatus Duméril

MALE

16. The Wolffian ducts prior to opening into the cloaca. The urinary bladder is on the ventral side, × 45.

FEMALE

17. The common uterus and the separate Wolffian ducts lie against the cloacal wall, × 56.

PLATE 4

[Photomicrographs from a series of transverse sections passing through the posterior region of the gut with the urinogenital ducts behind the kidneys.]

Cornufer corrugatus Duméril

FEMALE

FIG. 18. Uterine aperture on the verge of closure after spawning. The Wolffian ducts lie against the cloacal wall, × 62.

Cornufer novæ-britannæ (Werner)

FEMALE

19. The common uterus is pushed inside the cloaca within a common urinogenital papilla with the Wolffian ducts lying above them, × 56.

RHACOPHORIDÆ

Rhacophorus otilophus Boulenger

MALE

20. The Wolffian ducts behind the kidney region. Note also the glandular walls of the ducts, × 56.
21. The Wolffian ducts lying separate above the cloaca. Note the villose walls of these ducts, × 62.
22. The Wolffian ducts open separately into the cloaca, the left duct having opened already. The urinary bladder has also opened ventrally, × 62.

Philautus longicrus Boulenger

MALE

23. The Wolffian ducts open separately into the cloaca, the left duct having opened already, × 130.

PLATE 5

[Photomicrographs from a series of transverse sections passing through the posterior region of the gut with the urinogenital ducts behind the kidneys.]

MICROHYLIDÆ

Kaloula picta Duméril et Bibron

FEMALE

FIG. 24. Separate openings of the uteri. The left utterus has already opened and the right prior to opening, × 45.

Kalophrynus pleurostigma pleurostigma Tschudi

MALE

25. Opening of the urinary bladder into the cloaca. The separate Wolffian ducts still lie outside the cloacal wall. Note also the villose projections in these ducts, × 45.
26. The right Wolffian duct prior to opening into the cloaca. The left duct still lies outside, × 45.
27. Separate openings of the Wolffian ducts; the right duct has opened already, × 45.

Oreophryne annulata (Stejneger)

FEMALE

28. The confluence of the Wolffian ducts. The common uterus still lies against the cloacal wall, × 62.
29. (0.36 mm after fig. 28.) The common uterus and Wolffian duct lie inside a urinogenital papilla within the cloacal lumen, × 62.